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Climatic design requirements are established to define the environments that equipment may need to survive and/or operate in at some time in its life cycle. The requirements are based on an acceptable level of risk that the equipment will be usable when needed. These requirements form the basis of tests and ultimately the success or failure of the item in operational use. This article is intended to clarify some misconceptions in the design and test community as to what climatic design requirements really mean and how they should be used in the acquisition process.

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DETERMINING CLIMATIC DESIGN REQUIREMENTS IN THE AGE OF TAILORING

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Abstract

Climatic design requirements are established to define the environments that equipment may need to survive and/or operate in at some time in its life cycle. The requirements are based on an acceptable level of risk that the equipment will be unusable when needed. These requirements form the basis of tests and ultimately the success or failure of the item in operational use. This article is intended to clarify some misconceptions in the design and test community as to what climatic design requirements really mean and how they should be used in the acquisition process.

Background

Designing equipment to operate in and survive the adversities of the natural environment is neither easy nor straightforward. No single set of numbers can be used to cover all potential scenarios for every piece of equipment. The relatively new concept of tailoring was intended to address this, but pockets of resistance still remain. MIL-STD-210C, "Climatic Information to Determine Design and Test Requirements for Military Systems and Equipment," dated 9 January 1987 was developed to facilitate tailoring the design and testing of equipment. Never-the-less, the hot and cold atmospheres provided in MIL-STD-210A, dated 2 August 1957 are still used. Military aircraft are often designed to a low temperature operational requirement (on the ground) of -40°C without any other considerations. One need only to think about their own involvement in DT&E to come up with more examples.

Most of the problem stems from a natural resistance to change. People familiar and comfortable with a way of doing business are reluctant to learn or try new approaches. Also, the application of tailoring, whereby design and test requirements are not the same for all systems, but are based on the anticipated life cycle, performance and safety requirements, and economic considerations for each item, requires considerably more effort.

There has been much dialog regarding the presentation and use of climatic data for design and testing in publications of the Institute of Environmental Sciences and elsewhere. This brief article is intended to add some perspectives that may not have been adequately articulated in previous discussions.

Function of MIL-STD-210C

MIL-STD-210C provides a standardized approach for factoring the natural environment into requirements documents. However, considerable thought must be given to where, when, and how often a system will be required to perform. How it will get there and how it will be stored need to be evaluated, as does safety and survivability. All of these factors are interrelated and ultimately drive the climatic values to which a system will be designed. With this in mind, MIL-STD-210C performs the following functions:

1. Provides climatic data, not requirements. The Standard provides information on the natural environment to determine climatic requirements. The actual climatic design requirements depend on the factors mentioned above as spelled out by the procurring department or agency.

2. Allows for tailoring. The climatic data in the Standard are provided for both worldwide and regional types of climate. Data are also provided for the worldwide upper air environment up to 80km altitude.

3. Enables trade off analyses. Climatic values associated with several risk levels enable economic trade-offs versus the ramifications of backing off to less extreme requirements. Also, the Standard includes references from which the data were taken and other sources of information to better evaluate design requirements.

Climatic Data

The Standard provides climatic data that have low risks of occurrence. They are in the form of frequency of occurrence during the most extreme month at the worst location for each climatic element. These values are normally associated with operational requirements established by the procuring agency. Equipment may not operate when the operational requirements are exceeded, but should not be permanently damaged either.

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Long-term extremes, values that occur only once in 10, 30, or 60 years, are also provided. These values have a much smaller risk of occurring than the operational requirements. When these values are exceeded the equipment may become permanently damaged (or require major repairs), or become a safety hazard. The use of these more extreme values is dictated by the procuring agency.

The climatic data for the above two considerations represent the values that would not be exceeded in design and testing of material. This does not imply that the range of values between extremes should be ignored. Performance at moderate values of each climatic element also needs to be addressed when trade-offs are made.

Tailoring

It was mentioned earlier that tailoring requires effort. Detailed life cycle evaluations are needed so that the environments that a specific piece of equipment will be exposed to can be determined. From the time a piece of equipment is manufactured, it will be stored, shipped (air, sea, land), stored again and ultimately used. At this point it should be relied upon to fulfill its intended mission.

The above process will ultimately result in a set of climatic requirements. However, the tailoring process does not end here. The natural environment will be affected by the platform on or within which materiel is located. It will result in more, or less, extreme conditions for the materiel. These induced conditions are the design criteria.

Creativity is a necessary part of the tailoring process. Smart design can and should be used to "beat the environment." A heated shelter while not part of the system as originally conceived may lower costs of a system for which design to extreme cold is a cost driver. The color of paint, and layers of insulation can have profound effects on induced conditions. High temperature design for a searchlight should not be based on the high temperature extremes in MIL-STD-210C that occur during the afternoon. They should be based on the highest overnight temperatures that can be taken from the high temperature diurnal cycle in the Standard.

The above examples seem like common sense, and they are. But it's surprising how many calls I get from DoD contractors that do not realize that the design criteria are the induced environments appropriate for the design of a specific item, not the values plucked out of MIL-STD-210C.

Trade-Offs

In the final analysis, economic or state-of-the-art limitations may necessitate reassessment of priorities. Although the term "all weather" is used to describe many DoD systems, it unfortunately deviates from reality. In fact, all systems are limited by environmental conditions to some degree. The challenge is determining an acceptable risk for those conditions.

While creativity is part of the tailoring process, integrity plays a role in making trade-offs. Unless a system can perform its intended mission with a high margin of safety, no amount of savings can be justified. Furthermore, the mission should not be understated. Most military systems need to be designed with a worldwide operational capability. Eliminating regions of the world that experience extreme environments from the design envelope should be done only if those areas can be conclusively ruled out for the entire life expectancy of the system.

Lessons Learned

A USAF technical memorandum on cold temperature requirements for aircraft on the ground, written in 1986, discusses low temperature values in MIL-STD-210B. It states that "technological impossibility and/or the expense required to obtain -60° degrees F Low Temperature operational capability have been major reasons to relax the design criteria and the Standard itself has often been considered unrealistic." This is the main reason why many aircraft are designed to -40°F, the basis for which is unknown. In another situation, a DoD subcontractor building a component for use on an aircraft questioned the validity of the temperature value at altitude because he felt it was too extreme. These are common reactions that I've heard from users of the Standard over the years. If the climatic data cause design problems, they are not realistic.

What turned out to be unrealistic in the two situations described above was the use of the climatic data. In the case of the aircraft design, the -60°F value was inappropriate because these extremes are for Siberia. Although aircraft may have to fly over Siberia, they need not be designed to take off from an airfield there. Regarding the question on temperature for the aircraft component, the temperature value in the Standard was correct. Upon questioning the subcontractor, it turned out that the component would be located within a dome on the aircraft and not directly exposed to the natural environment. Due to conduction of heat from the aircraft and aerodynamic heating of the dome, the induced environment would be far less severe. The subcontractor was so surprised that he could design to the induced conditions, he asked me to repeat this information for his staff on a conference line.

Recently I've had two calls regarding design problems with equipment being used in Saudi Arabia. In one case, field stored munitions were experiencing higher temperatures than values in the specifications. In the other case, generators were not operating properly because of problems with voltage regulators exposed to the desert heat. In both instances, the callers questioned if the high temperature values in MIL-STD-210C were unrealistically low! In these cases, the specifications did not properly address the impact of solar radiation and resulting induced conditions. Also, in the case of the field stored munitions, the more severe "long-term extremes" should have been specified to avoid permanent damage.

Conclusions

MIL-STD-210C contains presentations of climatic data formatted specifically for use in designing and testing military systems and equip-

ment. The presentations allow for selection of natural environment values based on an acceptably small risk of equipment inoperability or failure. The data themselves reflect the most accurate available assessment of climatic statistics associated with the levels of risk defined in the Standard. Problems associated with the engineering development of military systems to operate in and survive these environments reflect the adversity of overcoming extreme conditions, not the accuracy of the climatic values themselves.

The Standard allows for tailoring and enables trade-offs. Both of these are important components in determining the envelope of climatic conditions to which materiel will be designed. All of the environmental forcing functions synchronously acting on the materiel, or the platform on or within which it is located, should then be used to evaluate the induced conditions that are the design criteria.